NAMAL UNIVERSITY MIANWALI
DEPARTMENT OF ELECTRICAL ENGINEERING

Communication Systems (Lab)
LAB # 07
REPORT

Title :
Frequency Modulation and Demodulation

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Date Performed	22-April-2024
Marks	

Introduction

The purpose of this lab is to enable the students to write a code for frequency modulation and Demodulation using MATLAB. The students will also observe the modulation and demodulation using Communication Trainer, CT-3000.

Course Learning Outcomes

CLO1: Perform hardware experiments for modulation/ demodulation techniques as well as sampling of analog signals.

CLO2: Develop software simulations to observe the performance of analog and digital communication systems.

CLO4: Report desired results proofs and calculations.

Equipment

- Software
    - MATLAB

Instructions

- This is an individual lab. You will perform the tasks individually and submit the required files at the end of the lab.
- Plagiarism or any hint thereof will be dealt with strictly. Any incident where plagiarism is caught, both (or all) students involved will be given zero marks, regardless of who copied whom. Multiple such incidents will result in disciplinary action being taken.

Frequency Modulation

In Amplitude Modulation schemes, the amplitude of a carrier signal varies with the amplitude of the message signal. Therefore the information of the message is stored in the amplitude of the carrier.

As studied in class, two other parameters of the carrier signal, i.e. frequency and phase can also store the information content of the message signal, and the resulting modulation schemes are called frequency modulation and phase modulation respectively. They are also collectively known as angle modulation.

The generalized form of an angle modulated signal is given mathematically as

$$M(t) = A_c \cos(2pi\ f_c\, t + \phi(t))$$

Where

$$\phi(t) = 2\pi k_f \int_{-\infty}^{t} m(\tau)d\tau \quad \text{for FM}$$

In frequency modulation, the frequency rather than the amplitude of the carrier wave is made to vary in proportion to the varying amplitude of the modulating signal. A simple method to achieve FM is to vary the capacitance of a resonant LC circuit in a transmitter. Because the frequency of a radio wave is less vulnerable to noise than the amplitude, FM was originally introduced to reduce noise and improve the quality of radio reception.

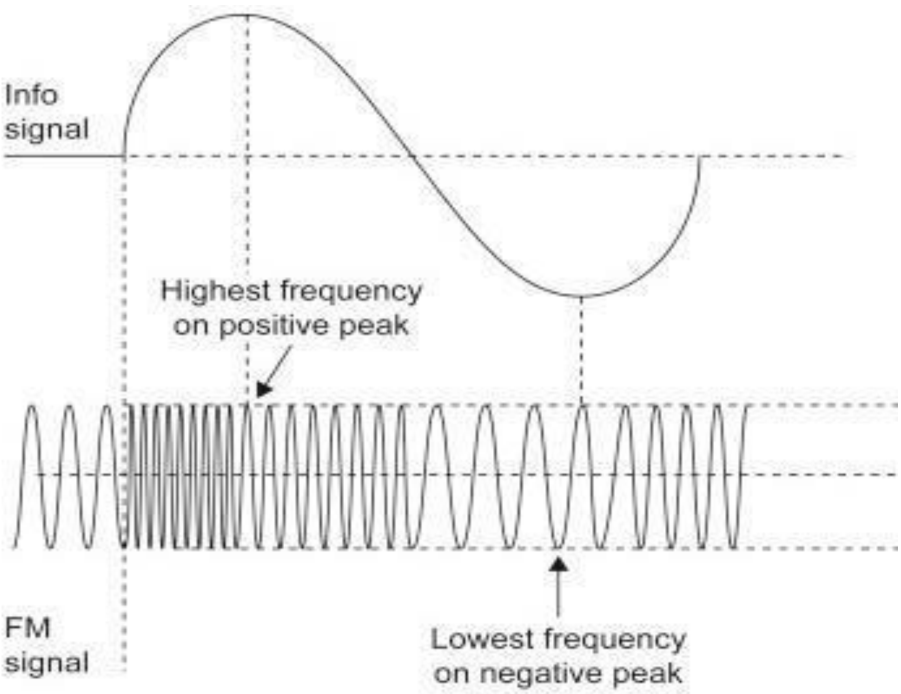


Figure: Frequency modulation demonstration

Task 1 – Frequency Modulation and Demodulation using MATLAB

The MATLAB function for Frequency modulation is fmmod (_) and the one for frequency demodulation is fmdemod (_)

Exercise 1

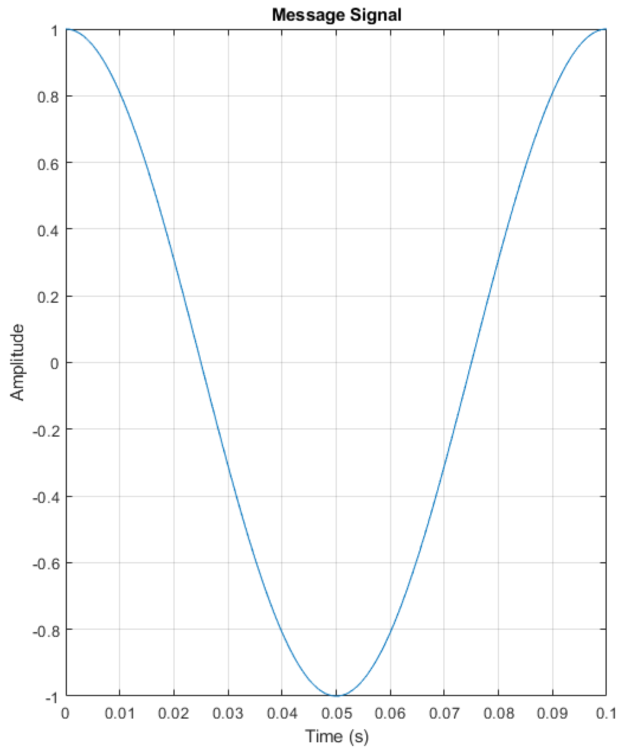
- Write a MATLAB code to modulate a sinusoidal signal (Am cos($2\pi f_m t + \theta$)) using frequency modulation.
- Use fm=10Hz , Am=1, θm=0, fs=10000, fc=500, Ac=1, θc=0, fredev=250.
- After defining the message signal frequency, carrier frequency, and the sampling frequency, the time scale can be defined as `t = 0:1/fs: 0.1;` for one time period of the message signal.
- Display the input signal, the modulated signal as well as the magnitude spectrum of input signal and Demodulated signal.
- Label all plots properly.

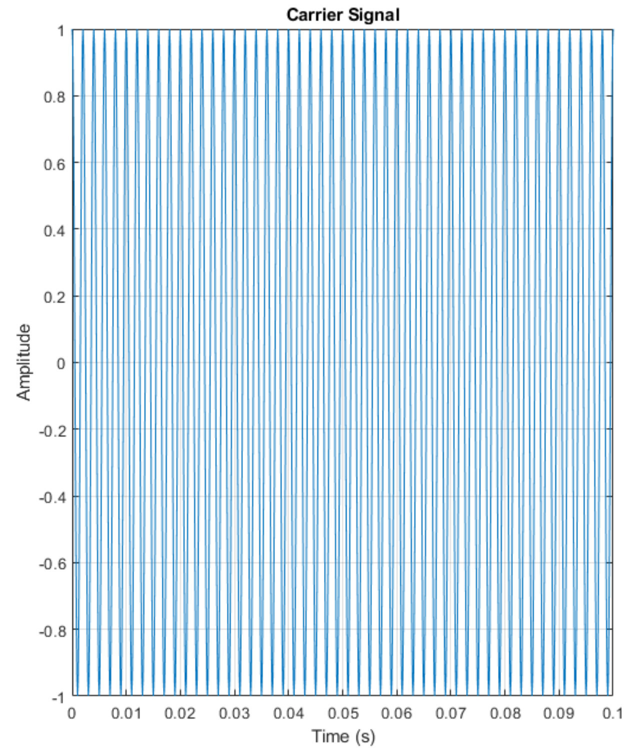
Change the value of frequency deviation factor and observe its effect on the modulated and recovered (demodulated) signal. Write your observations.

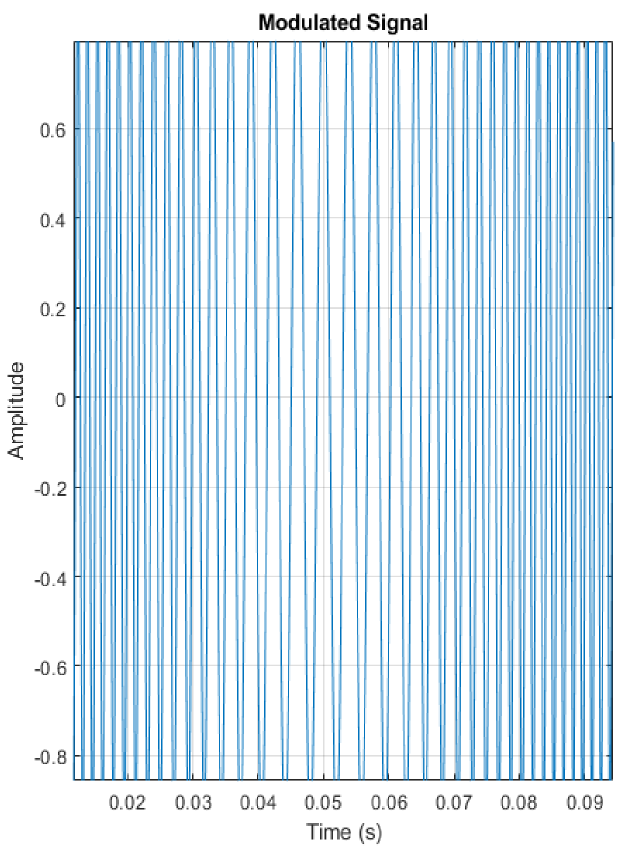
```
% Parameters
fm = 10;          % Message signal frequency (Hz)
Am = 1;           % Message signal amplitude
theta_m = 0;      % Message signal phase
fs = 10000;       % Sampling frequency
fc = 500;         % Carrier frequency (Hz)
Ac = 1;           % Carrier amplitude
theta_c = 0;      % Carrier phase
freq_dev = 250;   % Frequency deviation factor
% Time scale
t = 0:1/fs:0.1;   % Time scale for one time period of the message signal
% Message signal
message_signal = Am * cos(2*pi*fm*t + theta_m);
% Modulation
modulated_signal = fmmod(message_signal, fc, fs, freq_dev);
% Demodulation
demodulated_signal = fmdemod(modulated_signal, fc, fs, freq_dev);

% Magnitude spectrum of input signal
input_spectrum = abs(fft(message_signal));

% Magnitude spectrum of demodulated signal
demodulated_spectrum = abs(fft(demodulated_signal));

% Carrier signal
carrier_signal = Ac * cos(2*pi*fc*t + theta_c);
```

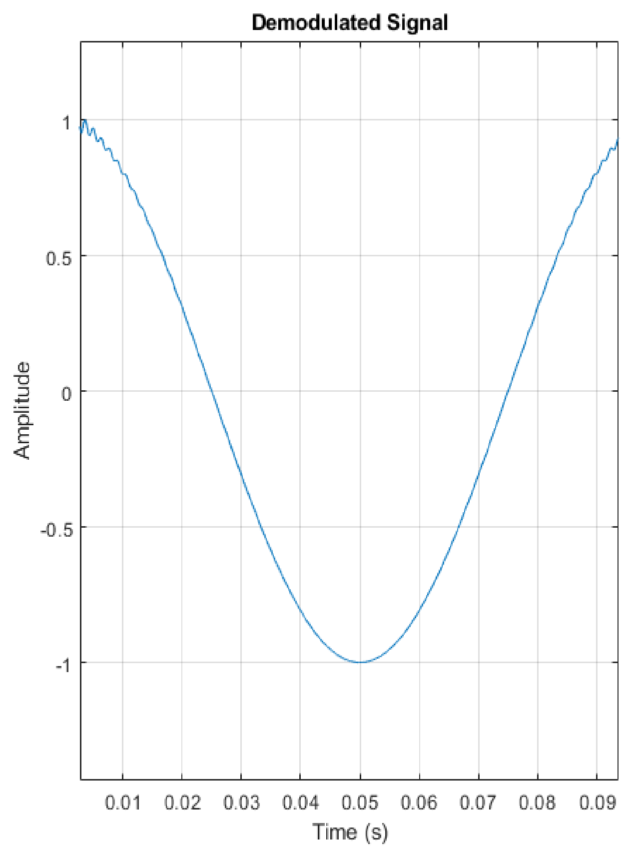
```matlab
% Plotting
figure;
subplot(1,2,1);
plot(t, message_signal);
title('Message Signal');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

subplot(1,2,2);
plot(t, carrier_signal);
title('Carrier Signal');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;
figure

subplot(1,2,1);
plot(t, modulated_signal);
title('Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

subplot(1,2,2);
plot(t, demodulated_signal);
title('Demodulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;
figure;

subplot(1,2,1);
plot(abs(input_spectrum));
title('Magnitude Spectrum of Input Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
grid on;

subplot(1,2,2);
plot(abs(demodulated_spectrum));
title('Magnitude Spectrum of Demodulated Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
grid on;

% Adjusting layout
sgtitle('Frequency Modulation and Demodulation');
```

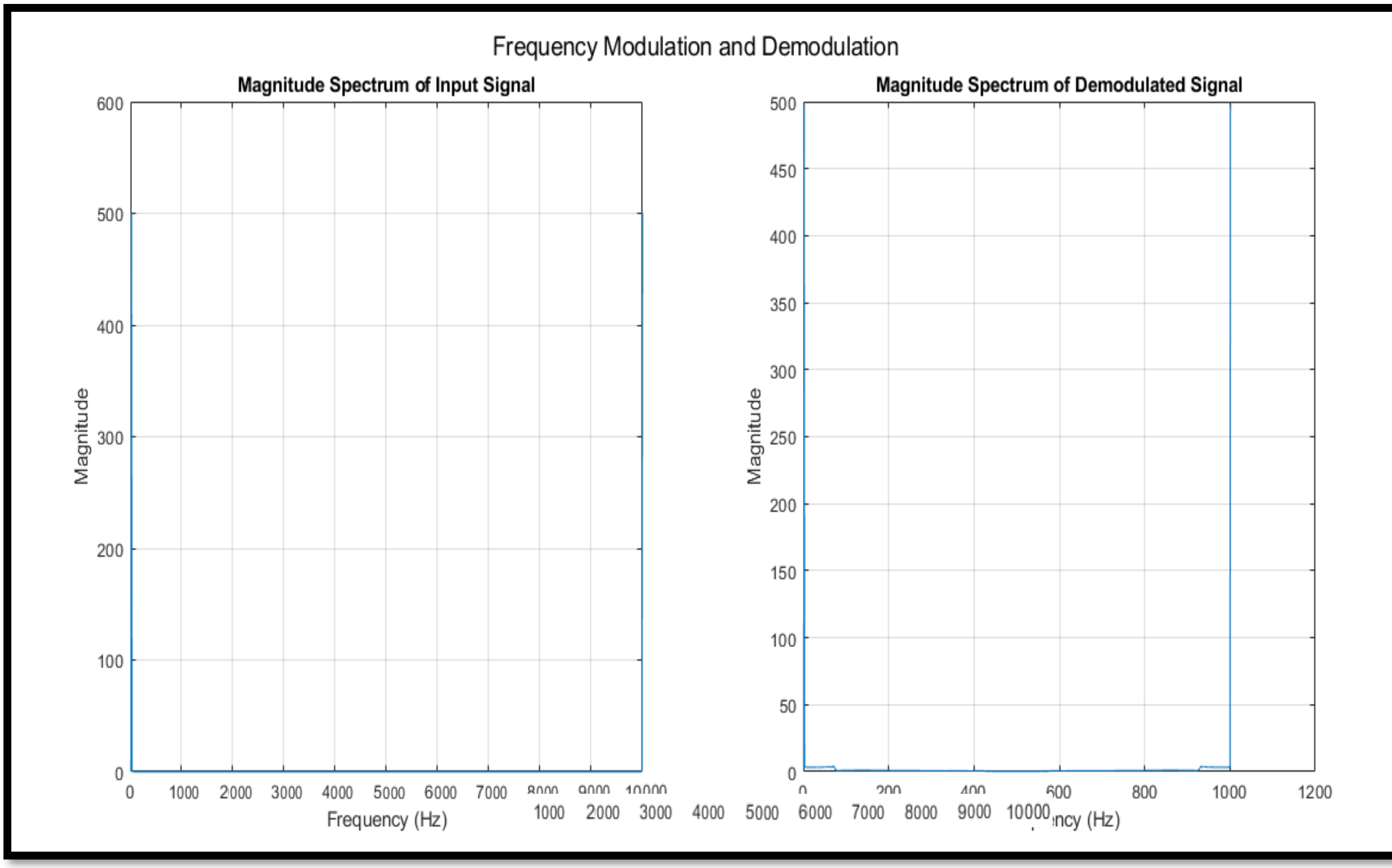
Output:


Message Signal
Amplitude
Time (s)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1


Carrier Signal
Amplitude
Time (s)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1


Modulated Signal
Amplitude
Time (s)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09


Demodulated Signal
Amplitude
Time (s)
1
0.5
0
-0.5
-1
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09



Explanation:

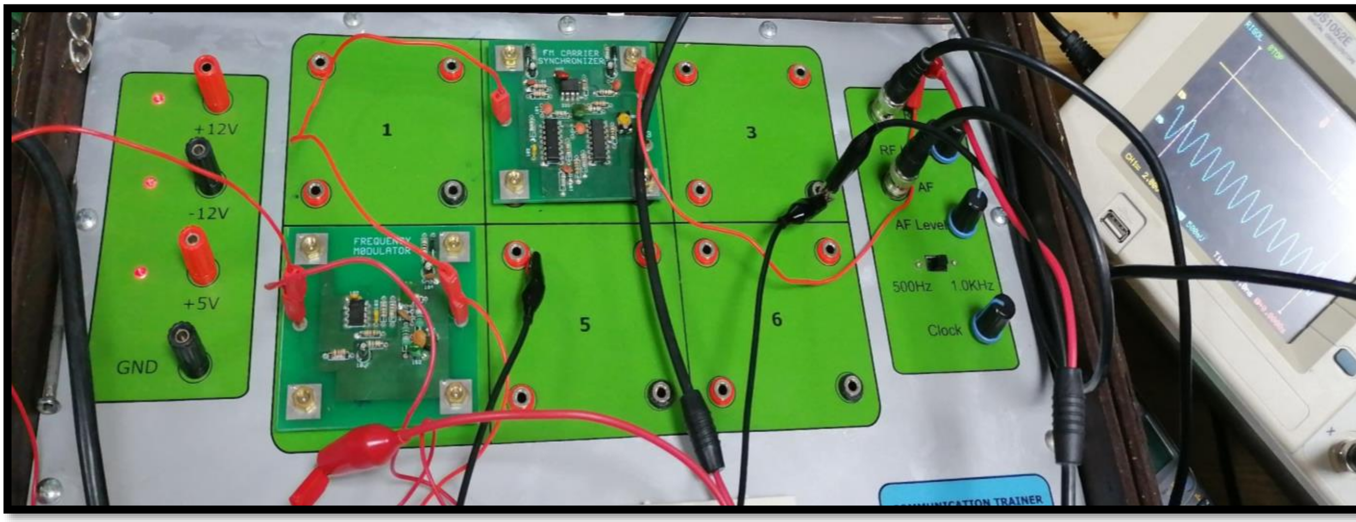
Firstly, I defined message signal frequency, amplitude and carrier frequency for the signals. Then, I generated a message signal using cosine function. Following that, I applied frequency modulation to message signal, and later on, I performed demodulation to recover the original signal. To visualize the frequency components, I computed the magnitude spectrum of both the input and demodulated signals. Finally, I plotted the message signal, carrier signal, modulated signal, demodulated signal and their corresponding magnitude spectra,

Task 2 – Hardware Procedure

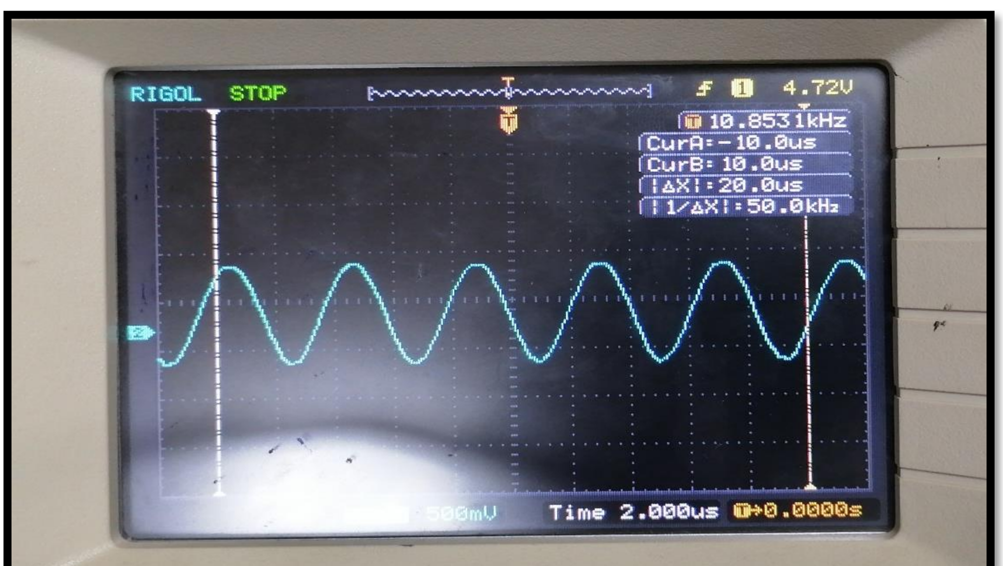
- First of all energize CT-3000 communication Trainer by applying 220VAC.
- For frequency modulation and demodulation, FM module is inserted in socket 4 and FM Carrier synchronizer module is inserted in socket 2.
- Set the message signal AF of 1 KHz and carrier signal RF of 10MHz directly from trainer at J1 port of FM module.
- Then, frequency modulated signal is observed, at J2 of FM module, on oscilloscope by using prob.
- Now, J2 of FM module is connected to J1 of FMCS module by using connecting wire and demodulated signal is observed at J2 on oscilloscope by using prob. Show the output to an instructor.

Observations:

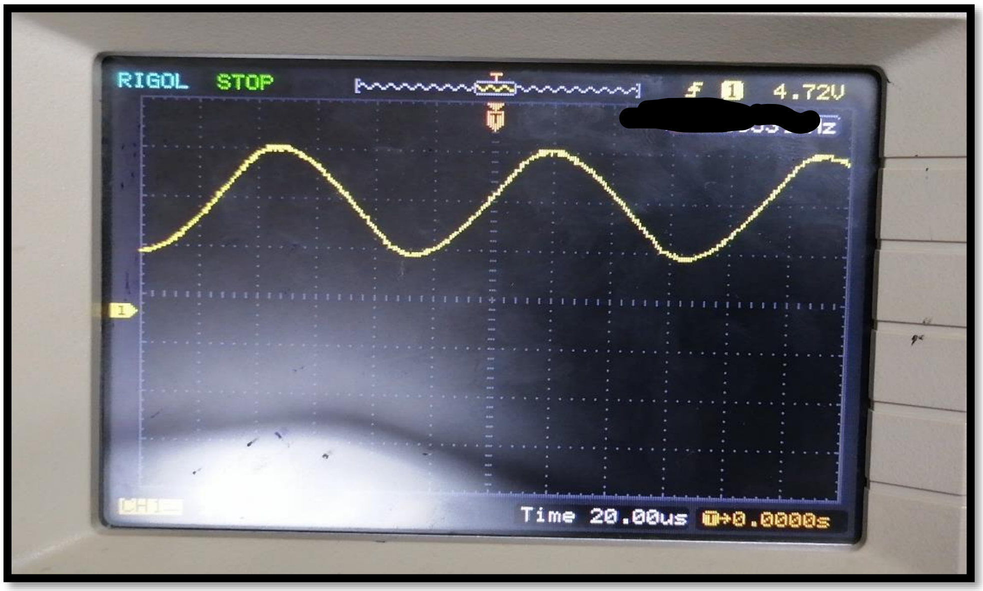
Circuit:



Input Waveform:

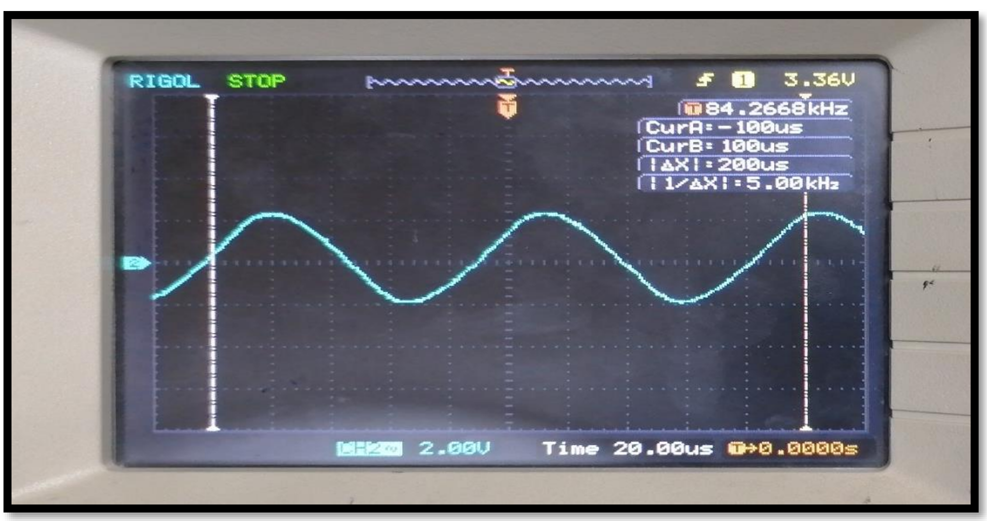


Carrier Waveform:



Modulated Waveform:

Demodulated Waveform:



Explanation:

In this task, we powered up CT-3000 trainer and inserted FM module into socket 4 & FM carrier synchronizer into socket 2. Setting message signal to 1KHz and carrier to 10MHz. We observed the modulated signal on oscilloscope at J2 of FM module. Then we connected J2 of FM module to J1 of FMCS and observed demodulated signal at J2 on oscilloscope.

Conclusion:

To wrap up, our software and hardware task on frequency modulation and demodulation with CT-3000 trainer was a success. By executing the procedure and observing the signals on oscilloscope, we confirmed the proper functioning of both FM and FMCS module. This practical exercise deepened our comprehension of communication systems in real-world applications

Com. Sys. Lab 7 Rubric

Method of Evaluation: Executable code, Report submitted by students **Measured Learning Outcomes**:

CLO1: Operate under supervision and practice hardware experiments for modulation/demodulation techniques as well as sampling of analog signals..

CLO2: Develop software simulations to observe the performance of analog and digital communications systems.

CLO4: Report desired results proofs and calculations.

	Excellent 10	Good 9-7	Satisfactory 6-4	Unsatisfactory 3-1	Poor 0	Marks Obtained
Hardware Experiment (CLO1)	Excellent performance in hardware experiments for modulation	Good performance but lack of understanding	Slightly incorrect Hardware setup withproper understanding	Bad performance in hardware experiment	Experiment not performed	
Code (CLO2)	Correct code, easily understandable with comments where necessary	Correct code but without proper indentation or comments	Slightly incorrect code with proper comments	Incorrect code with improper format and no comments	Code not submitted	
Output (CLO2)	Output correctly shown with all Figures/ Plots displayed as required and properly labelled	Most Output/ Figures/ Plots displayed with proper labels	Some Output/ Figures/ Plots displayed with proper labels OR Most Output/ Figures/ Plots displayed but without proper labels	Most of the required Output/ Figures/ Plots not displayed	Output/ Figures/ Plots not displayed	
Answers (CLO2)	Meaningful answers to all questions. Answers show the understanding of the student.	Meaningful answers to most questions.	Some correct/ meaningful answers with some irrelevant ones	Answers not understandable/ not relevant to questions	Wrong Answers	
Lab Report (CLO4)	Report submitted with proper grammar and punctuation with proper conclusions drawn and good formatting	Report submitted with proper conclusions drawn with good formatting but some grammar mistakes OR proper grammar but not very good formatting	Some correct/ meaningful conclusions. Some parts of the document not properly formatted or some grammar mistakes	Conclusions not based on results. Bad formatting with no proper grammar/ punctuation	Report not submitted	
Total						